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ABSTRACT

This document is one of five learning packets on alternative energy (see note) developed as part of a descriptive curriculum research project in Arkansas. The overall objectives of the learning packets are to improve the level of instruction in the alternative energies by vocational exploration teachers, and to facilitate the integration of new content on energy into existing vocational programs. Each learning packet contains unit objectives, information, transparency masters, lecture outline, suggested activities, student assignment sheets, tests, and answers to the tests. This unit on nuclear energy covers the following topics: introduction to nuclear power; the basis for nuclear power; nuclear power plants; types of radiation; effects of radiation on humans; processing of uranium; radioactive waste; and nuclear fusion. A glossary is also provided. (KC)

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NUCLEAR ENERGY

INSTRUCTIONAL MATERIALS

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USE OF THIS PUBLICATION

The overall objective of this publication is to improve the level of instruction in the alternative energies by vocational exploration teachers.

The development of alternative sources of energy and the increasing demand for energy conservation require that vocational educators develop new curriculum and improve existing delivery systems. All vocational education instructors must begin to acquire a minimum background in alternative energy sources and must be prepared to respond in a positive way to the energy education needs within their areas of specialization. It is anticipated that the use of this prepared learning package will facilitate the integration of new content on energy into existing vocational programs.

INSTRUCTIONAL UNIT

This packet contains objectives, information, transparency masters, lecture outline, suggested activities, student assignment sheets, tests and answers to the tests. These materials have been printed on colored paper to code their use. The following key will help easily identify each use by color:

White - teacher instructional materials

Green - information materials, teacher and student use

Yellow - student assignment materials

Golden - tests, teacher controlled

Pink - answers to tests and assignments, teacher use only

One set of each is included in the learning packet. The teacher should reproduce enough of the student use materials to adequately furnish his class with the proper materials.

Objectives

Included in the packet are measurable objectives. These objectives state the goals of the unit of study in such a way that both teacher and student will know what performance is expected.

Information Sheets

Each unit of instruction has information sheets which contain essential facts for that unit. These sheets are coded green and are intended for both teacher and student use. If inadequate information is contained in the student textbook, the teacher may reproduce these sheets for student use.

Instructional Materials

Instructional materials included with the unit contain transparency masters, suggested teaching activities, a lecture outline and a bibliography. These sheets are white and intended for teacher use. Each teacher is encouraged to consider these materials as a starting point and to develop additional activities and teaching materials to meet specific needs.

Student Assignment Sheets

Assignment sheets are included to give students an opportunity to apply knowledge and skill acquired through reading assignments, lecture and practice. These sheets are yellow and may be reproduced for student use.

Tests

A test is included in each unit to enable the teacher to measure student achievement. These sheets are golden and should be reproduced only for testing purposes.

Answers

Answers to student assignments and tests follow each assignment or test. These are coded pink and should be restricted to teacher use only.

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UNIT OBJECTIVES

- To work and experiment with energy systems in order to gain an understanding of energy sources, conversion, transmission, storage and control.

- To provide an opportunity in which students can gain career information for entry into energy-related occupations.

- To develop problem-solving and creative techniques in working with energy systems.

SPECIFIC OBJECTIVES

- The student will demonstrate at an accuracy rating of 75% or above, his knowledge of be difference between fission and fusion reactions as measured by completion of the student assignment sheets.

- The student will demonstrate at an accuracy rating of 75% or above, his knowledge of the functioning processes of a nuclear reactor as measured by the unit test.

- The student will demonstrate at an accuracy rating of 75% or above his knowledge of the functioning safety of a nuclear power plant by completion of the student assignment sheet.

OUTLINE

I. INTRODUCTION

II. THE BASIS FOR NUCLEAR POWER

III. ANATOMY OF A NUCLEAR POWER PLANT

IV. TYPES OF RADIATION

V. THE EFFECTS OF IONIZING RADIATION ON HUMANS

VI. THE PROCESSING OF URANIUM

VII. RADIOACTIVE WASTE

VIII. NUCLEAR FUSION

IX. GLOSSARY

INTRODUCTION

Nuclear energy has been a part of our lives since long before the Manhattan Project during World War II developed the skills necessary for controlled fission. The material used to make fissionable products are in trace quantities in almost all the materials that make up our environment.

The debate over the necessity for nuclear power has been vigorous. The inclusion of nuclear energy as a section of the Alternative Energy Curriculum is intended to inform students what this subject really involves.

Not many years ago prospects for the nuclear industry were bright. Nuclear power generation of electricity was heralded as the cleanest, cheapest and most convenient form of power. It seemed certain to fill much of the vacuum caused by the predicted shortages of oil and gas. Then came the oil embargo of 1973-74 followed by a strong national pressure to use less electricity and conserve fuel. The growing demand for electricity slowed its rate of growth. Utilities found themselves overextended. They cancelled their orders for new reactors.

Meanwhile, public opinion changed from pro-nuclear to anti-nuclear. Opponents formed demonstrations at reactor sites. They raised safety questions at public hearings and filed suits to prevent the licensing of future reactors. Nuclear accidents such as the Three Mile Island accident seem to add support to the nuclear opponents.

Yet, nuclear energy is already providing about one-eighth of all the electric power generated in this country. In 1978, nuclear energy produced nearly 300 billion kilowatt hours (KWH) of electricity. Eighty percent of electricity produced in the state of Vermont comes from nuclear power; in Maine, 65 percent and in Connecticut and Nebraska, 50 percent. All this has come about in just over 20 years since the United State's first nuclear plant was put into service at Shippingport, Pennsylvania.

What, then, is the future of nuclear energy? Is it at a dead end? Will it recover from its current public opposition? The exact answers are not clear. However, here are some arguments and essential facts needed to understand the processes used in nuclear power generation.

THE BASIS FOR NUCLEAR POWER

The basis for nuclear power is that certain heavy elements in the earth's crust, such as uranium, have variations (called isotopes) that can be made to split or fission. When the nucleus of such atoms split, it results in fragments which together weigh slightly less than the original nucleus. This loss in weight (mass) is the result of the release of energy. The fissioning atom also gives off neutrons, heavy subatomic particles. Under the right conditions, these neutrons strike other fissionable atoms and cause them to split. This creates a chain reaction and releases a tremendous amount of energy.

A nuclear reactor is a device to stimulate this splitting of atoms, but under controlled conditions. The resulting energy, released as heat,

can be used to make steam to drive turbine generators and produce electricity. The scientific principle is simple; putting it into use safely, calls for complex and highly sophisticated engineering.

If you could look into the heart of a typical "pressurized water" reactor, you could see the reactor core, scores of thick bundles about 12 feet long, made of slender, shiny tubes. Each tube is a fuel rod, filled with 200 pellets of enriched uranium. Each pellet is small, about twice as thick as a pencil and slightly more than half an inch long. The energy content for each pellet is about the same as a ton of coal or four barrels of crude oil. Each pellet costs about $10.00.

A large reactor holds tens of thousands of fuel rods in which are sealed some eight million uranium pellets weighing about 100 tons. The capacity of such a reactor is roughly 1,000 megawatts (one million kilowatts) of electricity, enough for a city of 600,000 people. However, the life of this core is limited. One-third of the fuel must be replaced annually during the expected 30 to 40 year life of the reactor.

ANATOMY OF A NUCLEAR POWER PLANT

Although there are more controls necessary, and more safety precautions, a nuclear power plant to generate electricity operates on the same principles as plants powered by fossil fuels: heated water produces steam; steam drives a turbine that spins a generator; the generator produces electricity. The heat source for a nuclear power plant is the energy released from the fission or splitting of the nuclei of fissionable materials, principally uranium 235.

The process is simple. A neutron collides with a uranium 235 nucleus, splitting the nucleus in two. Part of the energy that held

the nucleus together is released as heat and the other neutrons in the atom are ejected. Hitting other uranium 235 nuclei, the neutrons continue a chain reaction with a release of more heat.

Energy from the chain reaction of the fissioning uranium in the reactor core heats the surrounding water. This super-heated water is pumped under pressure into the tubes of a steam generator. Heat from the tubes convert water in the steam generator into steam. The steam is used to turn the rotors of turbines. The whirling turbine shaft turns an electric generator which converts the power supplied by the nuclear reactor into electric power. The steam from the turbines after it is used, returns to water and is pumped back to the steam generator to be heated again. This type of reactor is known as a pressurized water reactor. It is the most common type in the United States today.

To increase or decrease the amount of heat from the reactor, the rate of fission must be controlled. Control rod assemblies made of material which soaks up neutrons and slow the fission process, are lowered into the core. To release more heat, the control rods are withdrawn from the reactor core. The operator can stop the fission process by completely inserting the control rod assemblies in the reactor.

TYPES OF RADIATION

Nuclear fission releases particles and rays which are called radiation. Two kinds of ionizing radiation are actually electrically charged particles: Alpha particles and Beta particles. Alpha particles travel in the air only inches before they are stopped. They can not penetrate the skin and are not a health hazard as long they are outside the body. However, if an alpha emitter, such as plutonium

dust, is inhaled, the heavy alpha particles can deposit all their high energy content directly in the very sensitive lung tissue and bring damage. Beta particles travel a few feet in the air. They can penetrate slightly into the body. They especially affect the bones and thyroid if Beta emitters are ingested. Gamma rays are short-wave, high-energy electromagnetic radiation, like X-rays. They pass easily into the body. It takes about three feet of concrete to stop gamma rays. Without a barrier gamma rays can travel many miles.

THE EFFECTS OF IONIZING RADIATION ON HUMANS

Some kinds of radiation, such as ordinary light are relatively harmless. But ionizing radiation, the kind produced by radioactive materials, is dangerous. Ionizing radiation is invisible, but it can cause serious damage to the cells of the human body. The long range effects may be cancer if the damaged cells go out of control and duplicate themselves wildly. Birth defects and genetic mutations may occur if the damaged cells produce abnormal arrangements of the DNA strands that govern heredity.

Exposure to radiation is measured in rems (Roentgen equivalent man). Radiobiologists regard a dose to the whole body of 600 rems as lethal. 100 rems to the whole body causes radiation sickness. 10 rems can damage the lymph nodes and spleen and decrease the bone marrow red blood cells. Some scientists believe there is a threshold below which radiation has no permanent effect. Many others insist that no radiation level is harmless. Most scientists believe it is safe to assume there is no safe level of ionizing radiation.

We receive some low-level natural radiation all the time. This radiation comes from sunlight and natural radioactive elements. From the natural and other man-made sources, the average person gets 200 millirems (200/1000th of a rem) of radiation annually. A nuclear reactor, properly operated, adds little to this dosage. Actually coal fuelled generating plants emit about the same amount of radioactivity because of the radium and uranium in the coal.

THE PROCESSING OF URANIUM

Uranium as it is found in nature, must go through a number of steps before it becomes the uranium 235 that is usable in reactors.

Mining	Uranium is present in all the rocks of the earth's crust, but useful deposits are small and scattered. Mines in New Mexico and Wyoming provide most of the 11,000,000 tons of ore needed annually by the nation's nuclear industry.
Conversion	At the mill, each ton of ore is crushed, ground and chemically treated to extract three pounds of uranium oxide in a concentrate known as "yellow cake." This is converted to uranium.
Enrichment	Heated to a gas, the uranium is fed into a gaseous diffusion device to increase the proportion of uranium 235, the isotope of uranium that will fission in a reactor.
Conversion to Fuel	Enriched uranium gas is converted to uranium dioxide powder and formed into fuel pellets, each equivalent to nearly a ton of coal. Millions of pellets in slender fuel rods make up a reactor core.
Fission Products	Fissioning uranium atoms split into lighter elements, known as fission products. Some such as strontium and cesium, are far more radioactive than uranium. This spent fuel, when taken from the reactor must be stored underwater. Later it might be reprocessed to recover materials for further use.
Reprocessing	In this operation, workers use remote control manipulators to separate uranium and plutonium from waste. They are protected by thick concrete and glass.

By-products — Certain radioisotopes from spent fuel are used for cancer therapy and as radioactive tracers in medicine.

Nuclear Waste — Radioactive waste that is not recycled must be stored with great care for long periods.

RADIOACTIVE WASTE

The problem of radioactive waste grows larger with each passing year. Some experts feel that this problem will eventually be the demise of the entire nuclear industry. These radioactive wastes may be divided into three groups:

1. High Level Waste: Spent fuel from nuclear reactors. A large reactor may produce about 30 to 40 tons a year. Another source of high level waste is by-products of the government weapons program.

2. Transuranic Waste: These contain high levels of radiation such as alpha particle emitters.

3. Low Level Wastes: These are slightly contaminated materials such as clothing, industry trash and sweepings, with only weak radioactivity.

The waste problem began more than 30 years ago when the United States started making plutonium for nuclear bombs and putting nuclear reactors in submarines. The defense waste is enormous; some 500,000 tons of highly radioactive material and 64 million cubic feet of less radioactive trash. It is stashed temporarily in tanks and burial sites on government reservations.

Most experts agree that dangerous long-lived forms of radioactivity would best be concentrated in solid form. Then it should be enclosed in protective canisters and stored hundreds or thousands of feet deep in suitable geological formations. Scientists are currently studying such possibilities as salt beds and granitedeposits.

Whatever method is used, long storage will be required. The length of time involves the half-life of the radioactivity of the isotopes. The half-life is the time it takes for half of the radioactivity to disappear. If the half-life is 30 years, half of the atoms disintergrate in 30 years, but half are still left. Within 10 half-lives, only one thousandth of the radioactivity is left. Most of the strong gamma emitters in nuclear waste have half-lives of about 30 years or less. Thus in 300 years they will be reasonably safe. Plutonium 239 has a half-life of 24,400 years. A quarter of a million years will pass before most of its radiation is gone.

In all cases, the wastes should not be stored in places where the ground water can reach them and where there is earthquake activity.

NUCLEAR FUSION

Safe energy? Energy from hydrogen, a component of water? That is the promise of fusion, the same energy process that fuels the sun. Fusion requires temperatures of a hundred million degrees celsius. At that temperature, nuclei of tritium and deuterium fuse into an unstable nucleus that gives off a high energy neutron, leaving a nucleus of helium. In a reactor, the neutron would give up its kinetic energy as heat. Such a theory is simply stated but difficult to achieve in application.

Scientists are researching two ways to cause fusion. One is to bombard the two atoms with high power laser beams; the other is to force the atoms together with powerful magnets.

It is not likely that fusion will be available for power generation use until the next century.

GLOSSARY

ALPHA PARTICLE - a positively charged particle emitted from a nucleus of uranium. It is composed of two protons and two neutrons.

BETA PARTICLE - a electron or positron emitted from a nucleus.

FISSION - a kind of disintegration of an atomic nucleus. The nucleus is excited by a neutron which strikes it, causing it to break into fragments and release energy.

GAMMA RAY - non-material short-wave radiation emitted from radioactive atoms. Gamma rays are extremely penetrating and offer a hazard to health.

IONIZING - capable of producing a charged particle.

NEUTRON - an atomic particle having no electric charge.

NUCLEAR ENERGY - energy held within the nucleus of an atom.

NUCLEI - the central part of an atom, which makes up most of the weight of the atom.

RADIOACTIVE - nuclear disintegration with emissions of corpuscular or electromagnetic radiation.

REACTOR - an assembly in which controlled nuclear fission takes place. Reactors are used as a source of thermal energy.

REM - abbreviation for Roentgen Equivalent Man. Equates the effects of different kinds of radiation on man to the effect of gamma radiation.

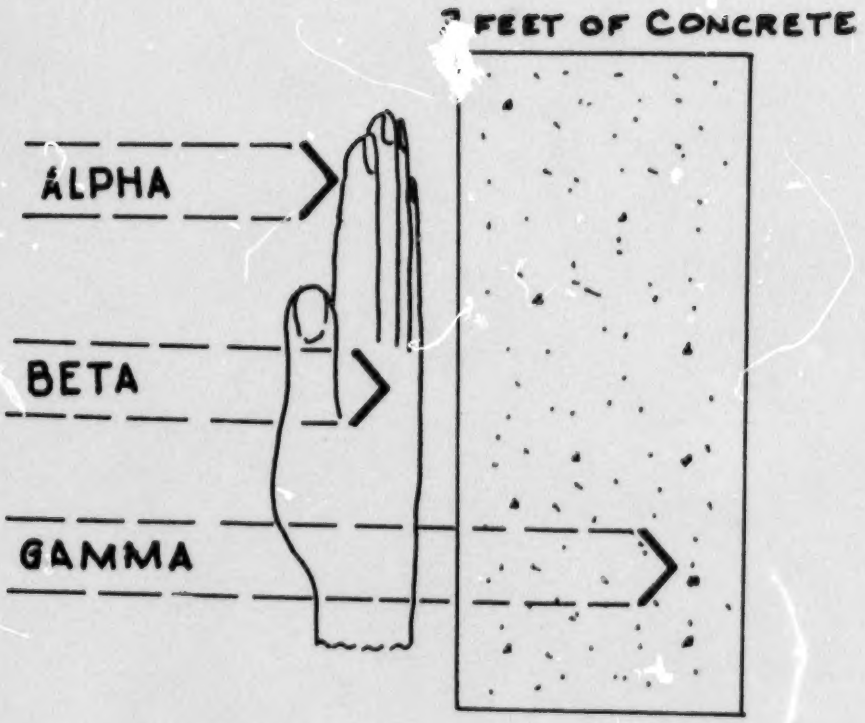
INSTRUCTIONAL MATERIALS

I. DIAGRAMS
   A. Fission
   B. Penetrating Power of Radiation
   C. Nuclear Fuel Cycle
   D. Fossil Fueled Generation
   E. Nuclear Fueled Generation

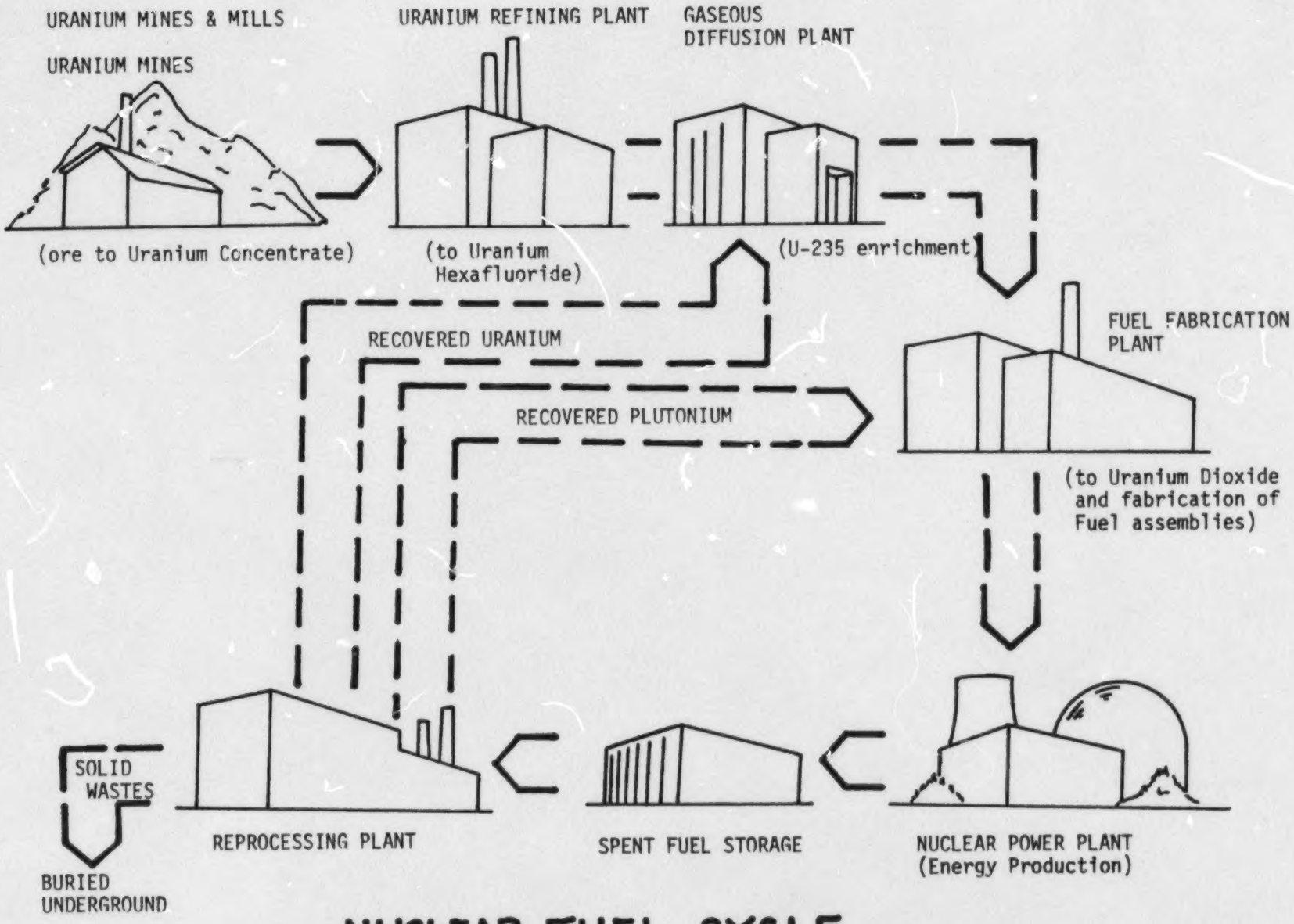
II. LECTURE OUTLINE

III. BIBLIOGRAPHY

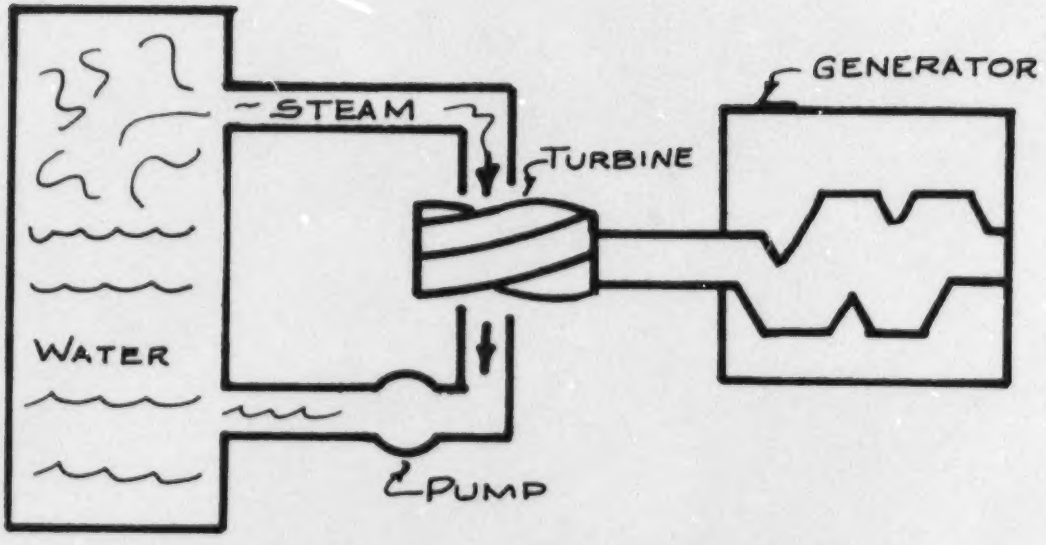
FISSION



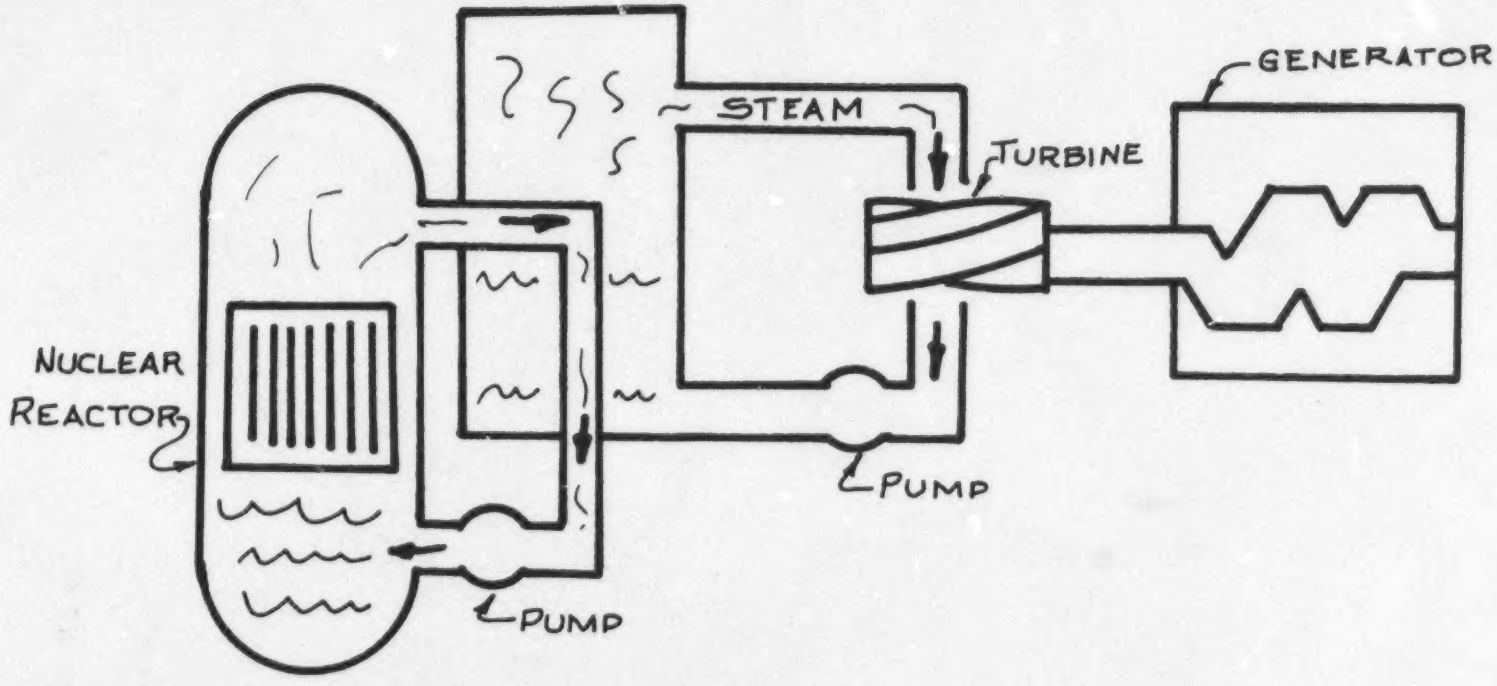
PENETRATING POWER OF RADIATION



NUCLEAR FUEL CYCLE



FOSSIL FUELED GENERATION



NUCLEAR FUELED GENERATION

LECTURE OUTLINE

I. INTRODUCTION

A. Nuclear energy has been part of our lives long before the Manhattan Project during World War II developed the skills necessary for controlled fission.

B. The materials used to make fissionable products are in trace quantities in almost all the materials that make up our environment.

C. The oil embargo of 1973-74 caused a slackening in the growth of electrical usage. This in turn caused orders for nuclear reactors to be stopped.

D. Public opinion has changed from pro-nuclear to anti-nuclear in many areas.

E. Nuclear energy is already producing one eighth of all electrical power generated in this country.

II. THE BASIS FOR NUCLEAR POWER

A. Fission is the process of continued splitting of uranium atoms nuclei. These nuclei give off neutrons which strike other nuclei and the process goes on in a controlled manner in a nuclear reactor.

B. The resulting energy from atomic fission is heat. This heat is harnessed to make steam that drives turbine generators to produce electricity.

C. The energy content of each uranium pellet is about the same as a ton of coal or four barrels of oil.

D. One third of the fuel in a nuclear reactor core must be replaced annually.

III. ANATOMY OF A NUCLEAR POWER PLANT

A. The "pressurized water reactor" is the most common type of reactor in the United States.

B. To increase or decrease the rate of fission and the amount of heat from the reactor, control rod assemblies are used. These rod assemblies act much like a blotter, soaking up free moving neutrons to control the rate of fission. When the rods are inserted into the core, they absorb the neutrons and slow the fission process.

IV. TYPES OF RADIATION

A. Two kinds of ionizing radiation are Alpha particles and Beta particles.

B. Alpha particles travel only a few inches in the air before they stop.

C. Beta particles can penetrate a short way into the body.

D. Gamma rays pass into and through the body.

V. THE EFFECTS OF IONIZING RADIATION ON HUMANS

A. Ionizing radiation, the kind provided by radioactive materials or X-ray machines, is dangerous. Though invisible it can cause serious changes in the cells of the human body. Its intense energy can destroy or distort molecules in cells. It breaks DNA strands in genes. The long range effects may be cancer.

B. From natural and man-made sources, the average person gets 200 millirems of radioactivity per year.

C. Coal plants emit about the same amount of radioactivity as a nuclear plant because of radium and uranium in the coal.

D. Radiobiologists regard a single dose to the whole body of 600 rems (600,000 millirems) as lethal.

E. Most scientists believe it is prudent to assume there is no safe level of ionizing radiation, even though we constantly get some radiation from our environment.

VI. THE PROCESSING OF URANIUM

A. Mining

B. Conversion

C. Enrichment

D. Fuel Conversion

E. Fission Products (In the Reactor)

F. Reprocessing

G. By-products

H. Nuclear Waste

VII. RADIOACTIVE WASTE

A. Many people feel that radioactive waste will doom the nuclear industry.

B. Three types of radioactive waste :

1. High level

2. Transuranic

3. Low level waste

C. The waste problem began more than 30 years ago when the United States started making plutonium for nuclear bombs and putting nuclear reactors in submarines.

D. Most experts agree that dangerous long lived forms of radioactive waste would best be concentrated in solid form. Then it should be enclosed in protective canisters and stored hundreds or thousands of feet deep in suitable geological formations. Scientists are currently studying such possibilities as salt beds and granite deposits.

E. In all cases the nuclear wastes need to be stored in sites where ground water can not easily reach them and where earthquakes are unlikely to happen.

VIII. NUCLEAR FUSION

A. Fusion reaction results from the combination of two light weight atoms, tritium and deuterium. The result is a high energy reaction and the formulation of a helium nucleus.

B. The method for the combination of the two substances is by bombarding the two atoms with high power laser beams or the compression of the two atoms by the use of a powerful magnet system.

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NUCLEAR ENERGY STUDENT STUDY SHEET

1. How long has nuclear energy been a part of our lives?
2. When did the Arabs have the "oil embargo"?
3. When and where was the first nuclear power plant built in the U.S.?
4. What is the function of the nuclear reactor?
5. What item is the heart of the nuclear power generation system?
6. Just how powerful are the pellets that go into the core of the reactor?
7. How much fuel must be replaced in the reactor annually?
8. What are the long range effects of ionizing radiation?
9. How far do Alpha particles, Beta particles, and Gamma Rays travel?
10. What is a millirem?
11. How many millirem does the average citizen in the U.S. get annually from natural and man-made sources?
12. What is a lethal does of radiation?
13. What is meant by "half-life"?
14. What is the difference between fission and fusion?
15. What are some different types of ionizing radiation?
16. What are the major sections of a nuclear power plant?
17. What are the eight steps of the processing of uranium?

NUCLEAR ENERGY

STUDENT ASSIGNMENT SHEET

Assignment No. 1

1. How do nuclear fusion and nuclear fission differ?

2. Can a nuclear power plant explode like a bomb? (answer with more than a yes or no)

3. What does the term "reprocessing" mean in relation to the nuclear industry?

NUCLEAR ENERGY

ASSIGNMENT ANSWERS

Assignment No. 1

1. How do nuclear fusion and nuclear fission differ?
2. Can a nuclear power plant explode like a bomb? (answer with more than a yes or no?
3. What does the term "reprocessing" mean in relation to the nuclear industry?

---

1. Fission involves the splitting of the nuclei of certain heavy atoms such as uranium.

   Fusion involves the joining of the nuclei of two very light atoms to form hydrogen. In both cases the nuclear reaction produces significant amounts of energy.

2. No. The uranium 235 generally used in thermal reactors is not sufficiently enriched to create a nuclear explosion. A nuclear plant could suffer a steam explosion under certain circumstances.

3. Reprocessing plants separate unused uranium, as well as plutonium 239 by chemical techniques from waste. Only by reprocessing can unused uranium be separated from spent fuel so that it can be irradiated in the breeder reactor to produce additional fuel.

N U C L E A R ENERGY

TEST

NAME_____

DATE _____

GRADE_____

MULTIPLE CHOICE (choose best answer)

___ 1. Nuclear energy has been part of our lives

a. long before World War II.
b. since we bombed the Japanese in 1945.
c. since the Cuban blockade in 1962.
d. none of the above

___ 2. In what year was the Arab oil embargo?

a. 1943 b. 1953 c. 1963 d. 1973

___ 3. The pioneer nuclear power plant in the United States went into service at

a. Washington D.C.
b. Little Rock.
c. Shippingport, Penn.
d. none of the above

___ 4. A nuclear reactor is a remarkable device to stimulate the splitting of nuclei on a grand but _____ scale.

a. daily b. uncontrolled c. controlled d. none of the above

___ 5. The heart of a typical "pressurized nuclear reactor" is

a. an oil burner.
b. a gas burner.
c. a nuclear core.
d. none of the above

___ 6. The energy content of each pellet that goes into a fuel assembly of a nuclear reactor is about

a. one gallon of gasoline.
b. one ton of coal.
c. one barrel of fuel oil.
d. none of the above

___ 7. In a nuclear reactor _____ of the fuel must be replaced annually.

a. one half
b. one third
c. one fourth
d. one fifth

___ 8. The long range effects of ionizing radiation can be

a. a heart attack.
b. a sun burn.
c. an upset stomach.
d. genetic mutation.

___ 9. Alpha particles travel in air a few

a. miles.
b. feet.
c. inches.
d. none of the above

___ 10. Beta particles travel in the air a few

a. miles.
b. feet.
c. inches.
d. none of the above

___ 11. Gamma rays travel

a. many miles.
b. only a few feet.
c. only a few inches.
d. none of the above

___ 12. A millirem is

a. 1000th of a rem.
b. 100th of a rem.
c. 10th of a rem.
d. none of the above.

___ 13. Annually, from natural and man-made sources, you get close to

a. 100 millirems.
b. 200 millirems.
c. 300 millirems.
d. 600 millirems.

___ 14. Radiobiologists regard a single dose to the whole body of _____ as deadly to most people.

a. 200 rems
b. 400 rems
c. 600 rems
d. none of the above

___ 15. The time it takes radioactive elements to decay is measured by its

a. clock.
b. calendar.
c. half-life.
d. none of the above

___ 16. The process that generates energy by combining atoms is called

a. fission.
b. fusion.
c. defission.
d. defusion.

NUCLEAR ENERGY TEST

TRUE OR FALSE (answer by placing T or F on the line provided)

___ 1. The scientific principle to produce electricity from nuclear fuel is complicated, but putting it into use safely is easy.

___ 2. All kinds of radiation are harmful.

___ 3. Ionizing radiation is harmless.

___ 4. The long range effects of ionizing radiation may be cancer and genetic mutation.

___ 5. You are bathed in low-level natural radiation all the time.

___ 6. A nuclear reactor, properly operated, adds little radioactivity to the environment.

___ 7. One of man's most sophisticated structures is a nuclear reactor and power generation plant.

___ 8. The nuclear plant operator can rapidly stop the fission process at any time.

___ 9. Radioactive wastes are not a large problem.

___ 10. They use lasers and magnets in fusion reactors.

NUCLEAR ENERGY TEST

LISTING

1. List three (3) kinds of ionizing radiation.

   a. _____

   b. _____

   c. _____

2. List five (5) sections of a nuclear power plant.

   a. _____

   b. _____

   c. _____

   d. _____

   e. _____

3. List 6 of 8 steps in processing uranium.

   a. _____

   b. _____

   c. _____

   d. _____

   e. _____

   f. _____

4. List three (3) types of nuclear waste.

   a. _____

   b. _____

   c. _____

NUCLEAR ENERGY

TEST ANSWERS

MULTIPLE CHOICE

1. A	5. C	9. C	13. B
2. D	6. B	10. B	14. C
3. C	7. B	11. A	15. C
4. C	8. D	12. A	16. B

TRUE OR FALSE

1. F	3. F	5. T	7. T	9. F
2. F	4. T	6. T	8. T	10. T

LISTING

1. Three (3) kinds of ionizing radiation:

   a. Alpha particles
   b. Beta particles
   c. Gamma rays

2. Five (5) sections of a nuclear power plant:

   a. Reactor
   b. Control rod assembly
   c. Containment building
   d. Generator
   e. Condensers

   Also: turbines

3. Six (6) of 8 steps in processing uranium: (choose any six below)

   a. Mining
   b. Conversion
   c. Enrichment
   d. Fuel conversion
   e. Fission products (In the Reactor)
   f. Reprocessing
   g. By-products
   h. Waste

4. Three (3) types of nuclear waste:

   a. High level
   b. Transuranic
   c. Low level

OE029145

IMPORTANT !!!

EVALUATION QUESTIONNAIRE

Place
Stamp
Here

Arkansas Research Coordinating Unit
Education Building West, Room 305-D
Arkansas Department of Education
Little Rock, Arkansas 72201

Tape Here

Dear Teacher:

The evaluation of the completed materials is a critical step in the curriculum development process. It is required that all recipients of the materials prepared by the Alternative Energy Curriculum Project furnish such an evaluation. After you have had time to review this learning packet, complete this questionnaire and return it to the Arkansas Research Coordinating Unit.

This evaluation is for: (Check (✓) one)

( ) Alcohol Fuels ( ) Nuclear Energy ( ) Wind Power

( ) Conservation ( ) Solar Energy

Evaluate each section of the learning packet by placing a check (✓) in the Favorable or Unfavorable column. If the evaluation is Unfavorable, please state the reason in the space beside the section name.

Favorable	Unfavorable		
( )	( )	Information Section	_____
( )	( )	Instructional Materials	_____
( )	( )	Student Study/Assignment Sheets	_____
( )	( )	Tests	_____

Evaluate the following characteristics of the learning packets by placing a check (✓) in the appropriate response.

Readability: ( ) Too High ( ) Too Low ( ) Right Grade Level

Material Length: ( ) Too Long ( ) Too Short ( ) Correct Length

Technical Level: ( ) Too Technical ( ) Too General ( ) Right Technical Level

---

Do you plan to use this material in your classes? Check (✓) Will or Will Not. If Will, supply requested information. If Will Not, state reasons.

( ) Will

Name of Class _____

Grade Level of Class _____

School Name _____

( ) Will Not

Reasons _____

If additional Alternative Energy Curriculum materials would be of use in your classes, check (✓) those energy topics which should be developed.

( ) Bio-Mass ( ) Fuel Cells ( ) Methane ( ) Coal ( ) Geothermal

( ) Other _____

Thank you for your evaluation. Fold this questionnaire so the return address is on the outside. Seal with a small piece of tape. Place a first class stamp in the upper right hand corner and mail.